Development of learning algorithms for agile and adaptive mobile robots working in a human friendly environment.

Résumé du projet de recherche (Langue 1)

This project is directly linked with the topics addressed by the French Governments initiative “la nouvelle France industrielle”. Automotive manufacturing is exposed to a highly versatile market and must cater to customer’s expectation in terms of diversification and customization. Thus, flexibility and agility are key words of futurist production setups. The technological axis selected by R&D department of PSA GROUPE is to provide its facilities; especially in the final assembly lines process, with a new generation of collaborative mobile robots. The target here is not to replace the human operator but to offer a better collaborative environment for human operators with robots. PSA Groupe, relies on an internal process named “Usine Excellente” to define the strategies and the benefits of collaborative robotics in its plants. We aim to transform 80 workstations to collaborative ones in each final assembly by 2025, out of which 20% of the workstations have a risk of musculoskeletal disorders. The return on investment on each collaborative workstation is expected to be recovered in 18 months working 2 shifts. In order to achieve those objectives we need to improve the way we set up the applications of these collaborative stations. Achieving a task with a robot currently requires an expert to decide what trajectory it will follow and then to design a program that makes the robot follow it with precision. This is a long step that significantly slows down the adaptation of the production line. Customer expectations furthermore push toward more agile production lines in which each product can be tuned and adapted to their demand. Each product could be an original combination of options. Also, to setup a production line in which both humans and robots cooperate, the work to be achieved by the robot may vary depending on how the work will be shared between human and robot in that particular product. This is impossible today as each adaptation of the production may require up to 3 months, which is targeted to be reduced to 48 hours. It is particularly difficult to take into account in a traditional robot programming paradigm but it is essential in the perspective of agile production lines in which humans and robots collaborate. Adaptiveness is then a key to get agile production lines in which humans and robots can collaborate. It requires a complete shift in the paradigm used to program a robot. The program should not impose a fixed behavior but it should allow modifying the behavior of the robot depending on the situation and on the needs. Building a program adapted to each possible situation and then choosing the most appropriate one would be a tedious process. It is proposed here to follow a different approach and to use learning and adaptation algorithms in order to make the robot explore and find on its own, or with the help of some demonstrations made by a human, the actions to be performed. 1. First, the robot must be able to identify the situation and the goals to achieve. The identification will be handled with dedicated perception system and the goals will be provided through a dedicated interface. The situation and goals being known, the focus of this thesis will be on two open scientific questions that will require new solutions to be developed: - How to discover, via simulations, sets of behaviors that can achieve a particular goal in a given situation, and give flexibility in the sense that they can be easily modified if new constraints appear or if the situation is slightly modified? - How to efficiently transform simulated behaviors into stable and reliable ones in the real environment? This thesis aims at proposing original answers to these questions. 2. Given a goal and a set of constraints, it is relatively easy to discover an appropriate behavior with state-of-the-art methods. But our objective is to find many solutions when not all the constraints are a priori known, and make them as efficiently adaptive as possible to allow very quick modifications when the constraints change. The discovery of the behaviors will be performed through a two-step process: - In a preliminary phase, a divergent search process will build many different behaviors that are adapted to many different situations. This will require reasoning on potential constraints that are not known yet, on how behaviors can be adapted if the situation changes, and on how the behaviors can be stored to make selection as easy as possible. To tackle these issues, it will be necessary to develop new specific divergent search algorithms. - When a change occurs, new behaviors must be quickly proposed to provide flexibility to the production line. An ideal algorithm would not only rapidly select one new behavior; it would generate a class of potential behaviors that can be presented in a comprehensible way. This is because the final choice should be left to the human working alongside the robot. This raises relatively new questions for which few solutions exist, and developing an efficient algorithm will require new scientific results. Behaviors will be represented as dynamic motion primitives. They will be built from human demonstrations or transferred from the divergent search process performed in simulation. A local adaptation process will be proposed to compensate the lack of precision of the demonstration or the errors due to the discrepancies between simulation and reality. This work will be part of an effort done at the ISIR to advance programming by demonstration tools, aiming at faster learning, better generalizability and higher robustness.